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IRRIGATION ENGINEERING.

Irrigation: its Principles and Practice as a Branch of Engineering. By Sir Hanbury Brown, K.C.M.G. Pp. xv+301. (London: Archibald Constable and Co., Ltd., 1907.) Price 16*s*. net.

IRRIGATION is of such paramount importance to extensive tracts in India, and to the whole of Egypt, that it is in these countries that irrigation works have been carried out on the largest scale, and therefore the author, who has gained his experience in this branch of engineering in both these countries, is particularly well qualified for dealing with this subject; and by drawing his examples of works in illustration from both sources, and especially from Egypt, he has been able to present the principles and practice of irrigation in their grandest and most modern aspects. The whole object of irrigation is to supply water for agriculture to lands which are either devoid of adequate rainfall or on which the rain does not fall at a suitable period for the crops; and owing to the very unequal and irregular distribution of the rainfall in certain warm, and especially tropical, countries, large and extensive engineering works are often required to store and convey the abundant rainfall to arid regions at a distance. The simplest sources of water for irrigation are rivers which overflow their banks in the flood season, and inundate the adjacent low-lying lands, such as the Nile in Egypt, the Tigris and Euphrates in Mesopotamia, and the Indus in Sind. As, however, the land near the river bank is higher than the plains at the back, owing to the chief deposit of silt from the muddy flood-waters occurring when the overflow from the river loses its velocity on overtopping the banks, inundations would only occur with high floods, and would spread irregularly over the land according to variations in level.

To provide against these natural defects, and to obtain a uniform distribution of the fertilising silt as well as of the water, the basin system of irrigation was introduced, in which the land is divided by banks into a series of basins, and the water is admitted into the large low-lying basins at the back through sluices at the side of an embanked canal drawing its supply from the river above the highest up-stream basin of the set; whilst the smaller basins at a higher level adjoining the river are fed from a high-level canal deriving its water from the river further up-stream. By these arrangements the filling of the several basins in each set can be regulated with uniformity, and advantage is taken of a high flood to secure a large deposit of mud serving as manure. The mud is gradually deposited from the still water in the basins, and when the river falls the clear water is discharged, and the seed is laid in the damp mud. The basin system has been very extensively developed in Egypt; whereas in India canals draw the water from the rivers in flood-time, and irrigate the land by means of branch canals leading the water into field channels. Irrigation by inundation, however, only provides for winter crops; whilst the more valuable summer crops, such as sugar-cane, cotton, and rice, need water at definite intervals when the rivers are low, and protection from inundation during the flood season. This perennial irrigation enables two crops to be raised in the year, and more than doubles the value of the land; and the water stored by the Assuan dam has provided for the conversion of 450,000 acres from basin irrigation into perennially irrigated land. Besides rivers, wells, lakes, and artificial reservoirs afford sources for the supply of water for irrigation.

In India, wells irrigating 13 million acres are second only in importance to canals from rivers, which irrigate 17 million acres; whilst tanks enclosed by embankments, serving as primitive storage reservoirs collecting the rainfall and local drainage, irrigate 8 million acres; and the high concrete reservoir dam across the River Periyar, in the very rainy district of Travancore, stores up water which is discharged by a tunnel through the Ghats for irrigating the arid district of Madura, on the eastern side of the mountain range. Wells are used for irrigation in Egypt, but do not occupy at all the same important position as in India; though in olden times Lake Mœris provided a natural reservoir filled with water in flood-time, and supplementing the discharge of the Nile at its low stage, for which also the equatorial lakes act as regulators at the present time; whilst the reservoir formed by the Assuan dam supplies water for summer irrigation when the flow of the Nile is deficient. In the chapter on sources of supply it is stated that the storage required to secure the volume of water needed for the irrigation of summer crops for the whole of Egypt, during the hundred days in the year during which the flow of the Nile is at its minimum, is six thousand million cubic metres, of which one-sixth has been provided by the existing Assuan reservoir. The author enumerates five methods of increasing the storage, the first of which, namely, the raising of the Assuan dam, has been decided upon, since the book was written, for doubling the present supply; whilst the second proposal of building a second dam higher up the Nile has been rejected as impracticable. Little attention has been bestowed on the third project of forming a reservoir in the Wadi Rayan depression near the site of Lake Mœris; and a reservoir of this kind at the side of the river, when periodically filled up with muddy Nile water, would appear destined to be filled up before long with deposit.

The two last schemes for increasing the supply, advocated by Sir William Garstin, consist in effecting a great reduction in the loss from evaporation of the flow of the White Nile in passing through the swamps of the Sudd region, by diverting the discharge from the swamps into a straight cut, not less than 210 miles long, from Bor to the confluence of the River Sobat at Taufikia below the Sudd region and combining this increased discharge with the utilisation of the Albert Nyanza for storage, during the four months of flood discharge, by regulating its outflow so as to make up the deficiency during the remaining eight months. The new cut would have the great value of permanently increasing the flow of the Nile throughout the year below the confluence of the Sobat, but

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its construction would involve a very great expenditure, and occupy a long time; and it is very unfortunate that the fact of Lake Tsana, near the headwaters of the Blue Nile, being in Abyssinia is considered as precluding its utilisation as a storage reservoir for the irrigation of the Sudan and Egypt, with its great natural advantages of extensive area and commanding position. Several sections of reservoir dams are given in a chapter on dams and reservoirs, which, being drawn to various scales, are not readily compared, though forming an interesting series; but the foundations of the new Croton dam have had to be carried down more than forty feet deeper than shown on the section; and the Salt River dam, constructed for the irrigation of an arid district in Arizona, only about seventeen feet less in maximum height than the Croton dam, has the crest of its waste weirs raised the unprecedented height of 225 feet above the deepest part of the river-bed at the dam.

Interesting descriptions are given of the diversion weirs across rivers in India to raise their water-level for supplying inundation canals, and of the Zifta, Delta, and Assiout barrages for regulating the supply of irrigation water from the Nile, worked by Stoney's sluice-gates sliding on free rollers. The important function, however, performed by the Assiout barrage in raising the water-level of the river in August, 1902, during so low a flood of the Nile that the water could not flow into the great canals, until, by the prompt action of Mr. Webb in closing the gates, a sufficient head was obtained, for which the barrage had not been designed, should not be overlooked, as it preserved a large tract from a loss in non-irrigated crops of more than 600,000*l.* Moreover, the Esna barrage, in course of construction across the Nile between Assuan and Assiout, has been designed of sufficient strength to perform a similar duty when needed in perfect safety. Standard books, indeed, have been previously issued dealing with irrigation works on their grandest scale, in "The Irrigation Works of India," by Mr. Buckley, and "Egyptian Irrigation," by Sir William Willcocks; but the book under review will be very valuable for all persons interested in irrigation, by dealing in a single volume with and contrasting the principal works and systems of irrigation in these two great countries, and thus presenting a very comprehensive view of that most important subject of irrigation for the development of arid regions.

GEOLOGICAL EXPLORATIONS IN SINAI.

The Topography and Geology of the Peninsula of Sinai (South-eastern Portion). By W. F. Hume. Pp. 280+plates. (Cairo: National Printing Department, 1906.)

THE interesting region described in this memoir by the superintendent of the Geological Survey of Egypt extends from near Dahab along the western borders of the Gulf of Akaba to the promontory of Ras Mohammed. It lies east of Mount Sinai proper, or Gebel Musa, which is not, however, the highest of the Sinai mountains.

Attractive as the region is from an historical point of view, and interesting as it is to the naturalist, it offers few temptations for the ordinary tourist; and this not merely because it is an arid country. The Arab inhabitants are honest and obliging, but their dwellings consist simply of cloth stretched on a few poles, and placed under the protection of a rocky ridge. Keen as sportsmen, they use flint-lock guns, often of great length, serviceable for small game, as well as for the leopard, hyæna and ibex, which are the more abundant of the larger mammals. The country itself has been spoken of as "one of the most mountainous and intricate regions on the face of the earth," and Dr. Hume admits that much of it is a veritable wilderness with a bewildering complex of topographical structure. To the mountaineer it will hardly appeal, as there are no inaccessible peaks, but to the botanist and zoologist, who will find chapters specially devoted to them, and to the geologist, there are many attractions, not the least of which may be the absence of any extensive literature on their subjects.

The main portions of the area are composed of igneous and metamorphic rocks of ancient date—pre-Carboniferous at any rate. They rise in a mountain system trending north-east and south-west with a transverse chain that parts the region into two districts. The rocks include gneiss and sundry schists, granites, andesites, felsites, &c. The earliest sedimentary and volcanic rocks were penetrated by masses of granite, and some of the later intrusions have been arranged in strikingly symmetrical lines. The northern portion of this region is largely plateau, an old plain of marine denudation that appears only recently to have lost its capping of Nubian Sandstone. It has an average level of 1220 metres, except where cut by narrow gorges. In the southern portion, which comprises a multitude of ranges and peaks, the valleys are more deeply excavated, and in consequence the mountains, though lower, appear relatively higher than those in the north.

Still further north there is an area composed of barren Nubian Sandstone with overlying fossiliferous limestones of Cenomanian age, where the succession is greatly disturbed by trough-faults that have led to the production of rift valleys.

The structure, in a broad sense, is comparatively simple, as Dr. Hume observes, the main features having been produced by upheaval and dislocation rather than by erosion. Thus the principal mountain chain is due to a fault with a westerly downthrow of more than 5000 metres. Nevertheless, the influence of the rocks on the configuration of the land is well marked. The summits of many peaks are formed by felsite dykes; elsewhere parallel dykes of felsite and dolerite form the remarkable "dyke country," while the granite, which wears away in shells, presents curious rounded knobs and pillars. The coastal plain exhibits many features of interest in the presence of Miocene strata, and also of raised coral-reefs of Pleistocene age. Moreover, there are terraces of roughly stratified gravel in the principal valleys, as well as countless loose boulders. These were probably of torrential origin, distributed during the Glacial period, when, as Dr. Hume remarks, a small amount of *névé* might have accumulated on the Sinai mountains. Of still later date are some curious calcareous sandstones

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